RECORDING METHOD USING REACTION AND DIFFUSION, RECORDING MEDIUM RECORDED ON USING THE RECORDING METHOD, AND RECORDING/REPRODUCING APPARATUS FOR THE RECORDING MEDIUM

Technical Field

The present invention relates to a recording method using reaction and diffusion, a recording medium recorded on using the recording method, and a recording/reproducing apparatus for the recording medium, and more particularly, to a recording method using reaction and diffusion induced in a dielectric layer and a recording layer formed of a rare earth transition metal or alloys of rare earth metal and transition metal and transition metal by laser irradiation and enabling phase change recording and/or magneto-optical recording, a recording medium recorded on using the method, and a recording/reproducing apparatus for recording information on and reproducing information from the recording medium.

Background Art

Conventional recording media can be classified into magneto-optical recording media or phase change recording media. In magneto-optical recording media, such as mini disks (MDs), information is read by detecting the rotation of incident straight polarized light reflected from a magnetic film according to the magnetic force and the magnetization direction of the magnetic film. The rotation of the reflected light is known as the "Kerr Effect". In phase change recording media, such as digital versatile discs (DVDs), information is read based on the difference in reflectivity due to the different absorption coefficients of an optical constant between an amorphous recorded domain and a crystalline non-recorded domain of the recording medium.

FIG. 1 illustrates a conventional magneto-optical recording medium and the recording principle thereof. Referring to FIG. 1, a

magneto-optical recording medium includes an aluminum (Al) layer 111 as a reflective layer, which may be formed of silver (Ag), a dielectric layer 112 formed of, for example, SiN, a magnetic recording layer 113 formed of TbFeCo, a dielectric layer 114 formed of, for example, SiN, and a transparent polycarbonate layer 115, which are sequentially stacked upon one another. This recording medium is irradiated with a laser beam of about 5 mW emitted from a laser source 118 through a focusing lens 119 and a magnetic coil 116 to which a current is applied using a current source 117, so that the recording layer 113 is heated to a temperature of 200-400℃, and a magnetic field is generated in the laser-irradiated domain. As a result, the laser-irradiated domain is magnetized in a direction opposite to a non-laser-irradiated domain. Magneto-optically recorded information can be magneto-optically reproduced. In FIG. 1, the magnetization direction in the non-recorded domain and the recorded domain is denoted by downward and upward arrows, respectively.

FIG. 2 illustrates a conventional phase change recording medium and the recording principle thereof. Referring to FIG. 2, a phase change recording medium includes an aluminum (Al) layer 121 as a reflective layer, which may be formed of Ag, a dielectric layer 122 formed of, for example, $ZnS\text{-}SiO_2$, a recording layer 123 formed of, for example, GaSbTe, a dielectric layer 124 formed of, for example, $ZnS\text{-}SiO_2$, and a transparent carbonate layer 125, which are sequentially stacked upon one another. The phase change recording medium may further include a protective layer (not shown) between the recording layer 123 and each of the dielectric layers 122 and 124 so as to block a reaction diffusion between these layers. The phase change recording medium is irradiated with a laser beam of about 10-15 mW emitted from a laser source 128 through a focusing lens 129 so that the recording layer 122 is heated to about 600℃, and a laser-irradiated domain becomes amorphous. This amorphous laser-irradiated domain has a reduced

absorption coefficient k regardless of the change of refractive index n of an optical constant (n, k). The information recorded by phase change can be reproduced by phase change. The reduction of the absorption coefficient k means that the amorphous domain on which information is recorded by laser irradiation becomes more transparent and has a smaller reflectivity. In general, the absorption coefficient is about 3.0 for a crystalline, non-recorded domain of the recording layer and about 1.5 for an amorphous, laser-irradiated recorded domain.

The principles of magneto-optical recording and phase change recording are distinct from one another, so that they can be implemented only on specific recording media.

Many diversified methods of recording information using micro marks (pits) as in the phase change method and reproducing information from the recording medium regardless of the diffraction limit have been suggested. The most interested one among these methods is a reproducing method using a super-resolution near-field structure, which is disclosed in Applied Physics Letters, Vol. 73, No.15, Oct. 1998, and Japanese Journal of Applied Physics, Vol. 39, Part I, No.2B, 2000, pp. 980- 981.

FIG. 3 shows a conventional recording medium having a super-resolution near-field structure. Referring to FIG. 3, the recording medium includes a dielectric layer 132-2 formed of, for example, $ZnS\text{-}SiO_2$, a recording layer 133 formed of, for example, GeSbTe, a dielectric layer 134-2 as a protective layer formed of, for example, $ZnS\text{-}SiO_2$ or SiN, a mask layer 137-2 formed of, for example, Sb or AgO_x, a dielectric layer 134-1 formed of, for example, $ZnS\text{-}SiO_2$ or SiN, and a transparent polycarbonate layer 135, which are sequentially stacked upon one another. When the mask layer 137-2 is formed of Sb, the dielectric layers 134-1 and 134-2 contacting the mask layer 137-2 are formed of SiN. When the mask layer 137-2 is formed of AgO_x, the dielectric layers 134-1 and 134-2 contacting the mask layer 137-2 are formed of $ZnS\text{-}SiO_2$. The recording medium is irradiated with a laser

beam of about 10-15 mW emitted from a laser source 138 through a focusing lens 139 so that the recording layer 133 is heated to about 600℃, and a laser-irradiated domain becomes amorphous and has a smaller absorption coefficient k regardless of the change of refractive index n of an optical constant (n,k). In an irradiated domain of the Sb or AgO_x mask layer 137-2, the crystalline structure of Sb changes or AgOx decomposes, generating a probe as a near-field structure pointing at a region of the recording layer 133. As a result, information recorded on high-density recording media, which is recorded as micro marks that go beyond the diffraction limit, can be reproduced using such a super-resolution near-field structure.

However, in recording media having such a super-resolution near-field structure, since their mask layer and recording layer have similar transition temperatures, ensuring thermal stability to both of the mask layer and the recording layer during reproduction of information is considered as being important. Possible solutions to this problem include dropping the transition temperature of the mask layer and raising the transition temperature of the recording layer. However, it is not easy to make the difference in transition temperature between the mask layer and the recording layer larger due to the nature of the materials composing the two layers.

Disclosure of the Invention

The present invention provides a recording method using reaction and diffusion induced in a dielectric layer and a recording layer by laser irradiation and enabling phase change recording and/or magneto-optical recording, a recording medium recorded on using the recording method, and a recording and reproducing apparatus for recording information on and reproducing information from the recording medium. Information can be reproduced from the recording medium according to the present invention using either magneto-optical reproducing or phase change

reproducing method. The problem of thermal instability occurring in conventional super-resolution near-field recording media during reproduction, due to the similar transition temperatures of their mask layer and recording layer, is eliminated, so that information recorded on the recording medium according to the present invention can be reproduced regardless of the diffraction limit.

In accordance with one aspect of the present invention, as recited in claim 1, there is provided is a phase change method of recording information on a recording medium by changing absorption coefficients of optical constants of a recording layer and a dielectric layer of the recording medium by laser induced reaction and diffusion.

According to a specific embodiment of the phase change recording method of claim 1, the recording layer is formed of a rare earth transition metal, as recited in claim 2. In this case, the rare earth transition metal may be TbFeCo, as recited in claim 3.

According to another specific embodiment of the phase change recording method of claim 1, the recording layer is formed of alloys of rare earth metal and transition metal, as recited in claim 4.

According to another specific embodiment of the phase change recording method of any one of claims 1 through 4, the reaction and diffusion are induced at a temperature of 490-580℃, as recited in claim 5.

According to another specific embodiment of the phase change recording method of any one of claims 1 through 5, when the dielectric layer of the recording medium is constructed as a sequential stack of a protective dielectric layer, a mask layer formed of Sb, and a dielectric layer, laser light is radiated to induce reaction and diffusion in the recording layer and the protective dielectric layer and change the crystalline structure of the mask layer, so that information can be reproduced from the recording medium regardless of a diffraction limit, as recited in claim 6.

According to another specific embodiment of the phase change recording method of any one of claims 1 through 5, when the dielectric layer of the recording medium is constructed as a sequential stack of a protective dielectric layer, a mask layer formed of AgO_x stacked, and a dielectric layer, laser light is radiated to induce reaction and diffusion in the recording layer and the protective dielectric layer and decompose the mask layer, so that information can be reproduced from the recording medium regardless of a diffraction limit, as recited in claim 7.

According to another specific embodiment of the phase change recording method of any one of claims 1 through 5, the recording layer and the dielectric layer are simultaneously formed, so that the recording layer and the dielectric layer have a mixed structure including materials for the recording layer and the dielectric layer, as recited in claim 8.

In accordance with another aspect of the present invention, as recited in claim 9, there is provided a magneto-optical method of recording information on a recording medium by changing the magnetic spin direction in a recording layer while the recording layer and a dielectric layer of the recording medium are irradiated with laser to induce reaction and diffusion therein.

According to a specific embodiment of the magneto-optical recording method of claim 9, the recording layer and the dielectric layer are simultaneously formed, so that the recording layer and the dielectric layer have a mixed structure including materials for the recording layer and the dielectric layer, as recited in claim 10.

According to another specific embodiment of the magneto-optical recording method of claim 9 or 10, the recording layer is formed of a rare earth transition metal, as recited in claim 11. In this case, the rare earth transition metal may be TbFeCo, as recited in claim 12.

According to another specific embodiment of the magneto-optical recording method of claim 9 or 10, the recording layer is formed of alloys of rare earth metal and transition metal, as recited in claim 13.

According to another specific embodiment of the magneto-optical

recording method of any one of claims 9 through 13, the reaction and diffusion are induced at a temperature of 400-490℃, as recited in claim 14.

In accordance with another aspect of the present invention, as recited in claim 15, there is provided a recording method based on the physical properties of protruding record marks formed by laser induced reaction and diffusion in a recording layer and a dielectric layer.

According to a specific embodiment of the recording method of claim 15, the recording layer is formed of a rare earth transition metal, as recited in claim 16. In this case, the rare earth transition metal may be TbFeCo, as recited in claim 17.

According to another specific embodiment of the recording method of claim 15, the recording layer is formed of alloys of rare earth metal and transition metal, as recited in claim 18.

According to another specific embodiment of the recording method of any one of claims 15 through 18, the reaction and diffusion are induced at a temperature of 400-490℃, as recited in claim 19.

According to another specific embodiment of the recording method of any one of claims 15 through 19, when the dielectric layer of the recording medium is constructed as a sequential stack of a protective dielectric layer, a mask layer formed of Sb, and a dielectric layer, laser light is radiated to induce reaction and diffusion in the recording layer and the protective dielectric layer and change the crystalline structure of the mask layer, so that information can be reproduced from the recording medium regardless of a diffraction limit, as recited in claim 20.

According to another specific embodiment of the recording method of any one of claims 15 through 19, when the dielectric layer of the recording medium is constructed as a sequential stack of a protective dielectric layer, a mask layer formed of AgO_x, and a dielectric layer on the recording layer, laser light is radiated to induce reaction and diffusion in the recording layer and the protective dielectric layer and decompose

the mask layer, so that information can be reproduced from the recording medium regardless of a diffraction limit, as recited in claim 21.

According to another specific embodiment of the recording method of any one of claims 15 through 19, the recording layer and the dielectric layer are simultaneously formed, so that the recording layer and the dielectric layer have a mixed structure including materials for the recording layer and the dielectric layer, as recited in claim 22.

In accordance with another aspect to the present invention, as recited in claims 23 through 44, there are provided recording media recorded on using any recording method of claims 1 through 22.

In accordance with another aspect to the present invention, as recited in claims 45 through 66, there are provided recording and reproducing apparatuses for any recording medium of claims 23 through 44. A recording and reproducing apparatus according to the present invention is either a phase change recording and reproducing apparatus or an magneto-optical recording and reproducing apparatus. A recording and reproducing apparatus according to the present invention can reproduce information recorded on a recording medium using a phase change method using a magneto-optical reproducing method as well as a phase change reproducing method. A recording and reproducing apparatus according to the present invention records and reproduce information based on the physical properties of protruding record marks formed by laser induced reaction and diffusion in a recording layer and a dielectric layer.

Brief Description of the Drawings

FIG. 1 illustrates a conventional magneto-optical recording medium and the recording principle thereof;

FIG. 2 illustrates a conventional phase change recording medium and the recording principles thereof;

FIG. 3 shows a conventional recording medium having a super-resolution near-field structure;

FIG. 4 shows the structure of a recording medium according to the present invention;

FIG. 5 shows a change in the structure of a recording layer and a dielectric layer of the recording medium according to the present invention as a result of reactions and diffusion therein;

FIGS. 6A and 6B are graphs showing diffusion concentration of sulfur and oxygen, respectively, into a recording layer at different temperatures;

FIG. 7 illustrates the performance of the recording medium according to the present invention; (a) shows modulation characteristic versus recording power, (b) is an atomic force microscopic (AFM) photograph of a recording medium sample used for the modulation measurement, and (c) shows carrier to noise ratio (CNR) versus mark length;

FIG. 8 shows the performance of a recording medium having a super-resolution near-field structure according to the present invention; (a) shows CNR versus mark length; (b) shows CNR versus the number of reproductions; (c) shows CNR versus the power of reproducing laser light; and (d) is a top view showing the shapes of record marks formed in the super-resolution near-field recording medium; and

FIG. 9A is a graph of CNR when using phase change reproduction and magneto-optical reproduction methods to reproduce information recorded as marks by the phase change method according to the present invention; and FIG. 9B is a graph of CNR when using phase change reproduction and magneto-optical reproduction methods to reproduce information recorded as marks by the phase change and magneto-optical methods according to the present invention, respectively.

Best mode for carrying out the Invention

The structure and operation of the present invention for resolving conventional problems will be described in greater detail by means of the

following embodiments.

The structure of a recording medium according to the present invention is shown in FIG. 4. Referring to FIG. 4, a recording medium according to the present invention includes an aluminum (Al) layer 221 acting as a reflective layer, which may be formed of silver (Ag), a dielectric layer 222 formed of, for example, $ZnS\text{-}SiO_2$, a magnetic recording layer 223 formed of a material having a large affinity and reactivity to oxygen and sulfur, for example, TbFeCo, a dielectric layer 224 formed of, for example, $ZnS\text{-}SiO_2$, and a transparent polycarbonate layer 225, which are sequentially stacked upon one another. A material for the recording layer 223 should be capable of forming sulfides or oxides by diffusion into and reaction with the dielectric layer 222, like rare earth transition metal or alloys of rare earth metal and transition metal. Examples of such a material include a magneto-optical material, Ag-Zn, Ag-Zn, W, W-Fe, W-Se, Fe, etc.

In the recording medium having the structure of FIG. 4, information can be recorded using phase change, as described with reference FIG. 2. In particular, the recording medium is irradiated with a 635-nm red laser beam or a 405-nm blue laser beam having an output power of 10-15 mW emitted from the laser source 128 (refer to FIG. 2) through the focusing lens 129, so that the recording layer 223 is heated to a temperature of 490-540℃ to induce reactions and diffusion in the recording layer 223 and the dielectric layers 222 and 224. A laser-irradiated domain of the recording layer 224, where reactions and diffusion have occurred, has a smaller absorption coefficient k of an optical constant (n,k) that is nearly zero, compared with a non-irradiated domain of the recording layer having an absorption coefficient k of about 4. Accordingly, information can be recorded on the recording medium using phase change.

Another embodiment of a recording medium according to the present invention may have a super-resolution near-field structure as

shown in FIG. 3. In this case, the aluminum layer 221 acting as a reflective layer is removed from the recording medium of FIG. 4, and a protective dielectric layer, a Sb or AgO_x mask layer, and another dielectric layer are sequentially deposited on the recording layer 223, instead of the dielectric layer 224. When this recording medium is irradiated with laser light, reactions and diffusion occur in the recording layer 223 and the protective dielectric layer. At this time, the crystalline structure of Sb changes when the mask layer is formed of Sb, and the mask layer decomposes when it is formed of AgO_x. Due to these phenomena in the recording medium, recorded information can be reproduced regardless of the diffraction limit. In addition, since the difference in transition temperature between the Sb or AgO_x mask layer and the TbFeCo recording layer is large, information can be reproduced without conventional thermal instability problems. A region of the mask layer that undergone the crystalline change serves as a probe. When the mask layer is formed of Sb, the protective dielectric layer and the dielectric layer on the mask layer are formed of SiN. When the mask layer is formed of AgO_x, the protective dielectric layer and the dielectric layer on the mask layer are formed of $ZnS-SiO_2$.

In the recording medium having the structure of FIG. 4, information can be recorded using a magneto-optical method, as described with reference to FIG. 1. In particular, the recording medium is irradiated with a 635-nm red laser beam or a 405-nm blue laser beam having an output power of 10-15 mW emitted from the laser source 118 (refer to FIG. 1) through the focusing lens 119, so that the recording layer is heated to a temperature of 400-490℃ to induce reactions and diffusion in the recording layer 223 and the dielectric layers 222 and 224. Since the laser beam is radiated through the magnetic coil 116 to which a current is applied from the current source 117, a magnetic field having a magnetization direction opposite to a non-laser-irradiated domain is generated in a laser-irradiated domain. Here, reactions obviously occur

in the recording layer 223 and the dielectric layers 222 and 224, but diffusion does not. Since the laser-irradiated domain of the recording medium, where reactions and diffusion occurred, and the non-laser-irradiated domain are magnetized in opposite directions, information can be magneto-optically recorded.

When recording information in the recording medium having the structure of FIG. 4 using phase change, the recording layer can be heated to a temperature of 400-490℃ to induce reactions and diffusion in the recording layer 223 and the dielectric layers 222 and 224 by the irradiation of 635-nm red laser light or 405-nm blue laser light having an output power of 10-15 mW emitted from the laser source 128, as illustrated in FIG. 2. In this case, actually only reactions occur, but diffusion does not. In a laser-irradiated domain of the recording layer 223 and the dielectric layers 222 and 224, a physical deformation, as illustrated in FIG. 5, occurs as a result of the reaction and diffusion in the recording layer 223 and the dielectric layers 222 and 224. Such a physical deformation resulting from the reaction, leading to a protruding record mark, in the laser-irradiated domain reflects an incident laser beam at a similar angle to the reflection angle of reproducing light used in a magneto-optical reproducing apparatus. In other words, due to the physical properties of the protruding record mark formed as a result of the reaction in the laser-irradiated domain, information can be recorded on the recording medium by phase change and can be reproduced from the same using a magneto-optical recording/reproducing apparatus. These recording and reproducing operations will be described later.

In the TbFeCo recording layer 223 and the $ZnS\text{-}SiO_2$ dielectric layers 222 and 224 of the recording medium according to the present invention, Tb_2S_3, FeS, CoS, CoS_2 and Co_2S_3 are derived as a result of sulfurization, TbO_2, Tb_2O_3, FeO, Fe_2O_3, Fe_3O_4, and CoO derived as a result of oxidation, and α-Fe, α-Co, α-Tb and α-Fe-Tb are generated as a result of crystallization. Si, Fe, and Co diffuse between

the recording layer 223 and the dielectric layer 222 and 224, and sulfur and oxygen diffuse into the recording layer 223.

FIGS. 6A and 6B are graphs of diffusion concentration of sulfur and oxygen, respectively, into the recording layer versus temperature. The concentration of sulfur in the recording layer is saturated at 490℃ and 510℃, as shown in FIG. 6A. The concentration of oxygen in the recording layer is not saturated at 490℃ but is saturated at 510℃, as shown in FIG. 6B. When a recording medium according to the present invention is manufactured with a super-resolution near-field structure as shown in FIG. 3, in which the recording layer is formed of a rare earth transition metal or alloys of rare earth metal and transition metal, since the transition temperature of the recording layer is greatly different from the transition temperature of the Sb or AgO_x mask layer, information recorded on the recording medium can be reproduced regardless of the diffraction limit, without thermal instability problems occurring in conventional super-resolution near-field recording media.

FIG. 7 shows the performance of a recording medium according to the present invention, in which (a) shows modulation characteristic versus recording power, (b) is an atomic force microscopic (AFM) photograph of a recording medium sample used for the modulation measurement, and (c) shows carrier to noise ratio (CNR) versus mark length. The modulation characteristic of (a) was measured by converting the difference in reflectivity due to the different absorption coefficients k between the irradiated and non-irradiated domains into an electrical signal. The CNR of (c) was measured while reproducing information recorded on the recording medium according to the present invention by irradiation of a laser beam of 15 mW using a general phase change reproducing apparatus.

As is apparent from (a) of FIG. 7, the recording medium according to the present invention, where the recording layer formed of TbFeCo is interposed between the dielectric layers formed of $ZnSiO_2$, shows good

modulation characteristic at a recording power of about 10 mW or greater, compared with a conventional phase change recording medium having a recording layer formed of GeSbTe between dielectric layers formed of $ZnSiO_2$ and a conventional magneto-optical recording medium having a recording layer formed of TbFeCo between dielectric layers formed of SiN. As is apparent from (b) of FIG. 7, larger record marks appear in the recording medium due to a greater degree of reactivity of the recording layer with increasing recording power. As is apparent from (c) of FIG. 7, the CNR is 45 dB or greater at a mark length of 500 nm. This good information reproduction property is attributed to a sharp drop in reflectivity rendering the laser-irradiated domain transparent.

FIG. 8 illustrates the performance of a recording medium according to the present invention having a super-resolution near-field structure; (a) shows CNR versus mark length; (b) shows CNR versus the number of reproductions; (c) shows CNR versus the power of reproducing laser light; and (d) is a top view showing the shapes of record marks in the recording medium. The super-resolution near-field structure of the recording medium of the present invention is the same as the conventional super-resolution near-field structure of FIG. 3, with the exception of the recording layer formed of a rare earth transition metal, TbFeCo. Recording was performing using 635-nm red laser light having an output power of 10 mW for the conventional recording medium and 15 mW for the recording medium according to the present invention.

Comparing information reproduction properties between the super-resolution near-field recording medium according to the present invention and the conventional one, as shown in FIG. 8A, the CNR is about 5-10 dB higher for all of the mark lengths in the recording medium according to the present invention than the conventional recording medium, indicating that the super-resolution near-field recording medium according to the present invention provides better information reproduction properties than the conventional one. Referring to FIG. 8B, it is apparent that the information reproduction properties, which are

measured as CNR, of the super-resolution near-field recording medium according to the present invention remain constant regardless of how much reproducing operations are repeated, whereas the information reproduction properties of the conventional recording medium remarkably degrade after the reproduction is repeated a certain number of times. FIG. 8C shows that the information reproduction properties of the super-resolution near-field recording medium according to the present invention remain constant at a reproducing laser power of 3.3 mW or greater, whereas the information reproduction properties of the conventional one sharply degrade at a predetermined reproducing laser power without a small tolerance. Accordingly, the super-resolution near-field recording medium according to the present invention can be reproduced by any reproducing apparatus manufactured by different makers, without degradation of reproduction properties, even at a higher reproducing power. Referring to FIG. 8D, record marks of 200 nm are seen as distinct. It is also expected that information can be recorded as marks having a length of 100 nm or less using 405-nm blue laser light.

FIG. 9A is a graph of CNR when using phase change reproduction and magneto-optical reproduction methods to reproduce information recorded as marks by the phase change method according to the present invention; and FIG. 9B is a graph of CNR when using phase change reproduction and magneto-optical reproduction methods to reproduce information recorded as marks by the phase change and magneto-optical methods according to the present invention, respectively. For the CNR measurement of FIG. 9A, phase change reproducing and magneto-optical reproducing apparatuses manufactured by Pulse Tec. Co. (Japan) were used. For the CNR measurement of FIG. 9B, a general phase change reproducing apparatus using 630-nm light and a lens having a 0.60-numerical aperture (NA) and a general magneto-optical reproducing apparatus using 780-nm light and a lens having a 0.53-NA were used.

Referring to FIG. 9A, for mark lengths of 250 nm or greater, the

CNR is about 40 dB or greater both when the phase change reproducing apparatus is used and when the magneto-optical reproducing apparatus is used. Therefore, the recording medium according to the present invention is compatible with both of the phase change reproducing and magneto-optical reproducing apparatuses. The physical characteristics of the laser-irradiated domain, where record bumps are formed by reaction and diffusion, i.e., the reflection angle of laser light at the record bump with respect to incident angle that provides a similar effect to the Kerr effect, are thought as enabling the magneto-optical reproduction. When recording information by laser induced reaction and diffusion, an additional magnetic coil commonly used in conventional magneto-optical recording can be used to change the magnetization direction. In this case, information can be reproduced at a higher CNR.

Although a magneto-optical recording apparatus using 780-nm laser light and a lens having a 0.53 NA was used for the measurement of FIG. 9B, nearly the same performance as when using the phase change reproducing apparatus can be achieved by changing the wavelength of reproducing laser light and the NA applied in the magneto-optical recording apparatus to 630 nm and 0.60, respectively, which are the same as those used in the phase change reproducing apparatus. For a mark length of 400 nm, the CNR is about 40 dB or greater both when the phase change reproducing apparatus is used and when the magneto-optical reproducing apparatus is used. Apparently, the recording medium according to the present invention is compatible with both of the phase change recording and magneto-optical reproducing apparatuses.

As described above, in a recording method according to the present invention, reactions and diffusion are induced in the dielectric layers and the recording layer of a recording medium by laser irradiation and enable phase change recording and/or magneto-optical recording. When information is recorded on a recording medium according to the method of the present invention and reproduced using information

recording and reproducing apparatuses according to the present invention, information reproduction properties are improved compared with conventional techniques. In addition, a recording medium according to the present invention, recorded on using the above method based on phase change recording and magneto-optical recording principles, is compatible with both of the phase change reproducing and magneto-optical reproducing apparatuses. Furthermore, the problem of thermal degradation occurring in conventional super-resolution near-field recording media due to the similar transition temperatures of their mask layer and recording layer is resolved, so that information can be reproduced from a super-resolution near-field recording medium according to the present invention regardless of the diffraction limit.